Pre–registration Synopsis

on

Process Optimization for Fabrication and Wear Characterization of Aluminium based Metal Matrix Composites

For the Doctoral Degree in Mechanical Engineering

Submitted
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1. Introduction

A composite material is a blend of two materials with various physical and synthetic properties. At the point when they are joined, they create a material which is specialized to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength, hardness, and stiffness. Classification of composite materials occurs at two different levels; the first criterion of classification is based on the matrix (binder) constituent. The main composite families encompass metal matrix composites (MMCs), and ceramic matrix composites (CMCs), polymer matrix composites (PMCs), and carbon matrix composites (CFMCs).

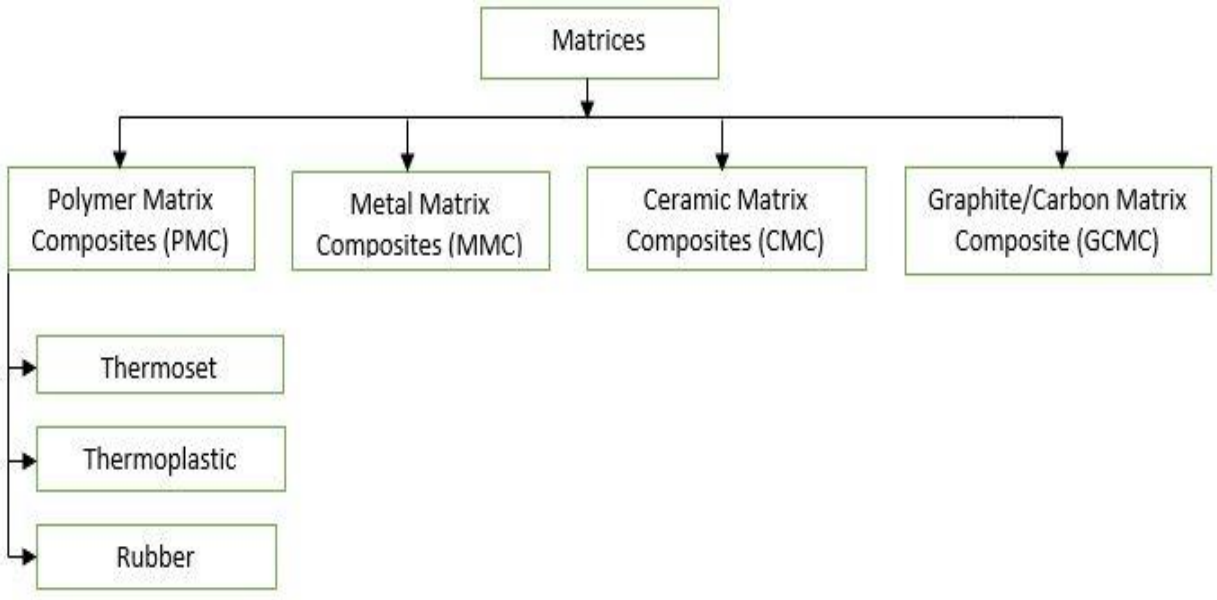

Fig.1 Classification based on matrices.

In recent decade, aluminium based metal matrix composites materials are finding increasing use in various application due to their several attractive properties like, light in weight, higher strength to weight ratio, corrosion resistance, durability, low density, high thermal conductivity, etc. Due to this variety of several properties of aluminium, this thing makes it suitable for various industrial applications [1].

The engineering applications in which aluminum-based composites play a major role are the manufacturing of cylinder block liners, automobile piston, brake disc and rotors, the frames of the bicycles etc. [2]. Although their different applications wherein the cylinder liners, revolving blade sleeves, and Al MMCs play an important role, more focus was drawn to both the brake drums, engine blocks, gear sections, piston crowns, crankshafts and drive shafts [3]-[7], aerospace and defense [8],[9] and other fields [10]. Those other fields of application point to something like a large number of components for which Al MMCs was designed and that best tribological but corrosion behaviour, high rigidity, strongest mechanical properties, however at high temperatures, were needed. [11].

2. Literature Review

Aluminum based composite materials are having superior properties such as low density with higher strength and thermal conductivities which makes it suitable for various industrial applications. The engineering applications in which aluminum-based composites play a major role are the manufacturing of cylinder block liners, automobile piston, the frames of the bicycles etc. [12]-[13]. Alaneme et. al. (2019) analysed the structural characteristics, mechanical and wear behaviour of stir cast Al-Mg-Si alloy-based composites reinforced with different weight percent of steel-, steel-graphite hybrid mix, and SiC-particles were investigated. The results show that the hardness of the composites increased approximately by 11% with increase in steel particles from 4 to 8 wt. %. For the same range of steel concentration, the ultimate tensile strength also increased with increase in steel wt. %. These strength values were all higher than that of 8 wt. % reinforced SiC by a margin of 3.2–24%. The specific strength and fracture toughness equally followed the

same trend with respect to steel concentration with strain to fracture, the exception where slight decrease (less than 4%) is observed. Vedrtnam and Kumar (2018) investigated the wear behaviour of aluminium reinforced with silicon carbide and copper. From the work, it was shown that the most influential parameter on the rate of wear of the composite was weight percentage of the reinforcements. Load and sliding speed were second and third, respectively in the order of dominance while sliding distance had the least effect.

Aluminium based composite materials reinforced with various ceramics have important industrial significance owing to best tribological and corrosion behavior, high stiffness and specific strength, low thermal coefficient, and best mechanical properties even at high temperature [14]. The SiC particles are having higher strength with improved mechanical properties and also withstand their behavior at a higher temperature. The B_4C powders are having neutron absorbing characteristics and also it has higher density and mechanical properties [15]. Hence, these composites are well suitable for the nuclear sector applications.

The metal matrix composite is fabricated through various techniques such as powder metallurgy, stir casting route, deposition methods, squeeze casting, vapor deposition methods, etc.

Among the available fabrication methods, stir casting is an appropriate technique for mass production and also it is also inexpensive [16]. In addition, the reinforcements are thoroughly dispersed in the molten state of matrix materials by the stirring process.

Many authors added reinforcements in Al MMCs like particulate alumina, silicon carbide, graphite, fly ash etc. to improve the mechanical and tribological properties of Al MMCs [17]– [20], others have used organic reinforcements like rice husk ash, natural fibers, glass fibers etc. [21]– [23]. Madhavarao et al. [21] investigated the tribological behaviour of aluminium alloy Al-7075 reinforced with SiC. Results illustrate that sliding distance and applied load have the highest impact on wear rate. Kanth et al. [22] investigated the Mechanical behaviour of fly ash/SiC particles reinforced Al-Zn alloy-based metal matrix composites fabricated. Findings suggest that with increase in

percentage of SiC and fly ash reinforcement, the ultimate tensile and yield strength were increased. Kumar et al. [23] investigated the mechanical behavior of Al MMCs reinforced with B_4C and MoS_2. Results indicate that by the addition of B_4C and MoS_2, wear rate of Al MMCs decreases. Mohanavel et al. [24] focused on the impact of SiC on the AA6351 aluminium matrix composites property. Results indicate that mechanical properties are increasing with increase in weight fraction of SiC. Alaneme et al. [25] showed that hardness of Al MMCs reinforced with Mg-Si increases with increase in weight fraction. Kumar et al. [24] investigated the mechanical behaviour and wear properties of TiC and graphite reinforced Al MMCs. Results indicate that with increasing in percentage of TiC, surface porosity and cracks increases. A limited research work is reported on Al MMCs reinforced with B_4C and SiC particles due to higher material cost. B_4C and SiC particles on aluminium metal matrix composites as gained more attention with low cost stir casting route [27]. Therefore, in this paper an overview is given on findings conducted by several authors concerning the influence of B_4C and SiC particles on aluminium metal matrix composites in the context of mechanical properties. There seems to be a market for high development and new composite materials in applied manufacturing complex environments. The hybrid composite materials fulfil the criteria of current applications in engineering.

The metallurgical but hardness characteristics of aluminium matrix composite materials were enhanced by Pandiyarajan et al. [28]. The Scanning Electron Microscopy (SEM) through Energy Dispersive X-RAY (EDX) study was being used to assess that hybrid composite's humongous dispersion. That hardness testing was carried but it was observed that only the superior then base aluminium became provided by the hybrid composite materials. Elanchezhian et al. [29] manufacture hybrid composites from base metal as Al 6061 aluminium alloy reinforced by various silicon titanium alloys, zinc, graphite, chromium by stir casting method. That processed mixture is heated at varying temperatures then aluminium composite mechanical properties become tested and their suitability becomes found towards multiple products. The scanning electron micrographs (SEM) of the tested sample revealed that the reinforcement particles were distributed

evenly with in matrix with little voids. Das et al. [30] Utilizing traditional stir casting routes, two formulations of HMMCs were made. As the matrix stuff, AA6061 was being used, then nano SiC / B_4C as reinforcements. Physical characteristics such as hardness also mechanical properties such as micro hardness, ultimate tensile strength including tensile strengths of those same HMMCs was verified by comparing with single reinforced micro / nano composites. It was observed that the HMMC had enhanced mechanical properties. As composites were improved with nano size reinforcements, major changes have been shown in ductility and porosity.

3. Research Gap

Aluminium based composite materials has been reported by several researchers. The prepared composite is well suited in wear application, automobiles parts such as piston, piston rings, brake rotor disc, connecting rod, transmission interior part chassis components, instrument shielding and as emergency reactor shutdown materials, e.g., scram balls. High precision and surface quality are essential in those nuclear applications. Moreover, the prediction model for better wear will provide a suitable guidance for the design of automobile components. Based on the literatures studies we observed that, no one focused on fabrication process parameters of composites which is very important stage in fabrication stage and also we try to combine stir casting method with centrifugal casting for fabrication process. This differentiates the research work and confirms the novelty of findings. Thus, our objective is to perform the experiments to maximize the wear resistance and optimum CoF by optimize process parameter of composite fabrication. The optimal conditions will be determined using RSM technique.

4. Objectives of the present work

• Fabrication of a new class of aluminium based composites reinforced with SiC varying percentage.

• To study the morphological behaviour of composites.

• To predict wear performance by experimentation with dry sliding wear test under various operating conditions.

• To identify the significant control factors and their interaction predominantly influencing the wear rate of composites by using RSM.

• Evaluation of mechanical properties of the composite such as: Density, Hardness, impact.

• To suggest a suitable application for the developed composite.

5. Research Methodology

Aluminium alloy 7075 alloy will be heated using the resistance furnace. The alloy will be heated to a higher temperature of 800^{o}C - 900 ^{o}C to melt it completely. The reinforcement chosen for this study will be SiC ceramic particles which also preheated at 300^{o}C. The preheated ceramic particles will be added to the molten state of aluminium alloy and the mixture will be stirred continuously by mechanical stirrer. Finally, the melt will be poured into the steel mold. The composite produced will have the varying weight contents of reinforcements. The composites will be prepared with Al and the addition of (10-20 wt. %) SiC particles and with varying particle particles size. The produced composites will be characterized based on the mechanical and tribological properties of the composite material made of aluminium reinforced with different percentages of SiC. The mechanical behaviour of this produced composite material will be analyzed by using tensile test, compression test and impact test. All mechanical tests will be performed at room temperature and as per ASTM standards. Tensile and compression tests will be carried out on universal testing machine. A Pin-on-Disc set-up is used for slide wear tests. Composite specimens, of required dimensions come in contact with a rotating steel disc while a

varying load will be applied. The weight loss measurements are carried out. For Morphological Characterization, the surfaces of specimens are examined by SEM, XRD.

Research Methodology

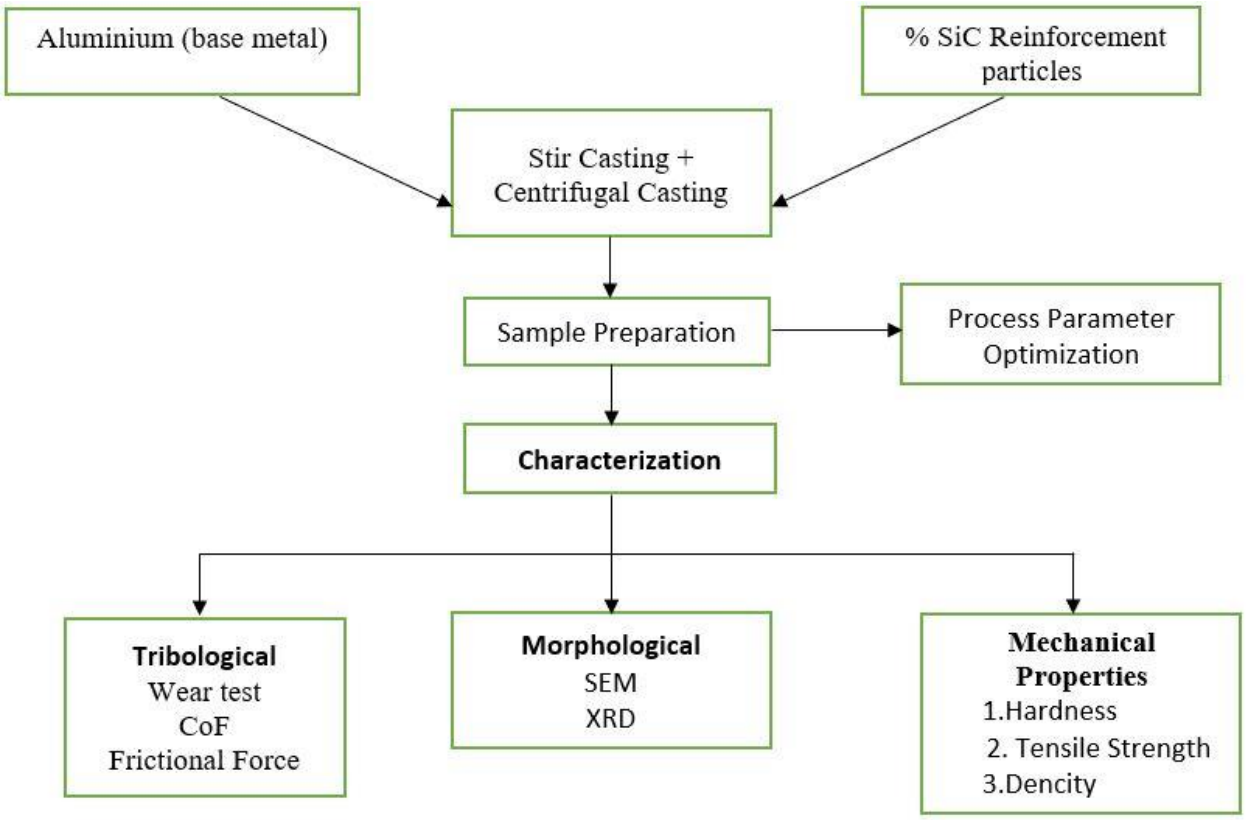

Fig.2 Research Methodology

6. Expected Outcome:

- Improved wear resistance property, successful analysis of Dry sliding wear response of composites by RSM Design of experiment and identification of significant factors affecting the wear rate of composites.
- Useful data base generation.
- The addition of ceramic particles in Aluminium to show a noticeable effect on mechanical properties of the composites.

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